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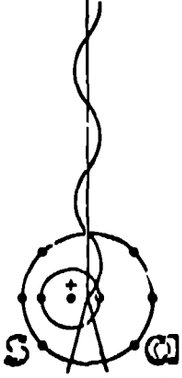

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SOIL MONITORING INSTRUMENTATION

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The Los Alamos Scientific Laboratory (LASL) has an extensive program for the development of nondestructive assay instrumentation for the quantitative analysis of transuranic (TRU) materials found in bulk solid wastes generated by Department of Energy facilities and by the commercial nuclear power industry. Included are wastes generated in decontamination and decommissioning of outdated nuclear facilities as well as wastes from old waste burial ground exhumation programs. The assay instrumentation is designed to have detection limits below 10 nCi/g wherever practicable. Because of the topic of this workshop, only the assay instrumentation applied specifically to soil monitoring will be discussed here.

Projects aimed at exhumation of outdated waste burial grounds and at measurement of transuranic migration in current burial grounds have necessitated developing techniques for rapid and quantitative analysis of transuranic materials in soil. One technique is the portable phoswich detector[1] for field surveys. The system in use is shown in Fig. 1. It consists of three components: the detector package (having a mass of 4.4 kg), a front chest module with count rate meter readout and scaler-timer, and main electronics package located inside the backpack. Total mass of the system is 8.8 kg. The system is similar in use and application to the field FIDLER[2] which uses a thin NaI detector. The phoswich detector is a thin NaI crystal coupled to a thicker CsI crystal, all coupled to a single phototube. Pulse shape discrimination allows the unit to reduce Compton-related backgrounds by a factor of 2-3 compared to the single thin NaI detector. This is for field use where shielding cannot be carried along. For stationary use where several inches of iron shielding can be added, the background reduction approaches a factor of 6 compared to thin NaI detectors. The phoswich system, when held at ground level, has an on-line and real time detection limit of less than 1 nCi/g for plutonium and below 100 pCi/g for ^{241}Am. The system is now being manufactured by a commercial nuclear instrumentation vendor.

A second soil assay instrument is a portable ZnS system[3] that provides a detection limit of 25 pCi/g for gross alpha counting for a 5-min count and a 30-min sample turnaround time. We use a commercially available ZnS alpha scintillator probe that is 10 cm in diameter with a single-channel analyzer equipped with a timer-scaler and HV supply (also commercially available). The system can be powered either by line or internal battery.

Soil samples are placed in plastic bags and the bags of soil are massaged to homogenize the sample sufficiently. Enough soil ($\sim$ 75 g) from the sample bag is carefully scooped into an 88-mm diameter x 13-mm deep plastic petri dish. The soil surface is leveled off so that it is even with the top of the petri dish; small rocks and debris are removed. The soil in the petri dish is dried under a heat lamp and allowed to cool before counting. If the soil sample is very wet, it is dried, ground up with a mortar and pestle to break up aggregates, and then returned to the petri dish for redrying. If the soil sample is not dry enough, moisture tends to condense on the mylar face of the probe during counting, reducing detector sensitivity. The petri dish is then placed in a depression in a black wooden holder and the probe is placed on top of the dish. The holder is black in order to minimize scattered light, since the 1 mg/cm^2 aluminized mylar covering the probe face is not completely opaque to light. Integral ribs on the probe provide a consistent 1.6-mm spacing between the top of the soil sample and the probe face. Samples are nominally counted for 5 min. The total amount of time that elapses from receipt of the sample to measurement results can be as little as 30 min.

The system is calibrated using a carefully homogenized soil sample spiked to 2000 pCi/g with ^{239}Pu. This sample gives 0.135 counts/min/pCi/g. The 1-sigma statistical error on the calibration factor is less than 3% for a 5-min count on samples $\geq$2000 pCi/G. System background (using an empty petri dish) is 0.5 - 1.0 counts/min. Natural alpha emitters in Los Alamos area soils result in background counting rates of 4-8 counts/min. An uncontaminated soil sample from the type of soil being measured is used to determine the natural alpha background.

This technique permits rapid assessment of alpha-emitter contamination in soils to low enough concentrations to efficiently direct large field operations. Because the soil samples are not completely homogeneous, a ZnS

gross-alpha analysis may not compare favorably with ^{239}Pu radiochemical analysis of the same sample (although the majority of our comparisons are within a factor of 2). However, we feel this disadvantage is offset by the advantage of being able to analyze a large number of samples in a relatively short time.

More selectivity and even better intrinsic detection limits are provided by a photon spectroscopy system.[4] An intrinsic germanium detector provides nondestructive assays of soil samples with detection limits less than 28 pCi/g for plutonium and less than 170 fCi/g for ^{241}Am in a 5-min count. The system is shown in Fig. 2. Using count times of four hours, the plutonium detection limit lowers (improves) to below 15 pCi/g. The ^{241}Am detection limit improves to below 50 fCi/g. Quantification is based upon the 60-keV gamma ray emitted in ^{241}Am decay and upon L x-rays (energies from 13 to 22 keV) emitted by TRU isotopes during their alpha decay. The detector is a single-crystal, intrinsic-germanium-planar detector (commercial available) with a surface area of 21 cm^2. Sensitivity is increased by incorporating a detector entrance window with a larger than normal surface area. A large volume Ge(Li) detector is added to the system (opposing the intrinsic germanium detector - see Fig. 2) to provide simultaneous fission product (^{137}Cs, ^{60}Co, etc.) analysis. LASL has built a second system with two opposing intrinsic germanium planar detectors for increased sensitivity for the TRU materials. The soil samples are approximately 20 g and are contained in custom plastic dishes with locking lids.

Our latest development in monitoring instrumentation is a newly designed portable multichannel analyzer[5] (MCA) that has much improved physical and performance characteristics over previous designs. Namely, the instrument is very compact (25 cm wide x 14 cm deep x 21 cm high) and has a mass of 4.2 kg (9.2 lb). The device has 1024 channels and is microprocessor-controlled. The instrument has most of the standard features of present laboratory-based pulse height analyzers, including CRT display, region of interest integration, etc. Battery life of the MCA is nearly eight hours, with full charging over night. An accessory case carries a small audio cassette recorder for data storage. The case also contains two different NaI(Tl) detectors. Another case contains a 10% efficient intrinsic germanium (HpGe) detector for very high energy resolution gamma ray spectroscopy. That detector (commercially available) is portable and can carry enough liquid

nitrogen for 10 hours of field use. All necessary electronics to acquire data from the various detectors are located on the detectors themselves. No additional power supplies, NIM equipment, etc., are necessary for field operation. A second MCA model has now been designed that has a digital cassette recorder built into the main chassis along with an extra PROM card that plugs into the top face of the unit and further customizes the software for a specific user or task. Figure 3 shows both versions of the MCA along with the portable intrinsic germanium detector.

While not directly related to soil monitoring, we have developed several CdTe detector-based instruments. Our latest is a small radiation warning "chirper"[6] that clips to a shirt collar. Shown in Fig. 4, the chirper demonstrates the application of CdTe crystals as GM tube replacements. The use of large crystals (when available) in portable micro-P type instruments has immediate applications in soil screening and environmental monitoring.

References

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2. J. F. Tinney and J. J. Koch, UCRL 50007-67-3, Lawrence Livermore Laboratory (1967) p. 6.

3. "Recent Developments for Field Monitoring of Alpha-emitting Contaminants in the Environment," A. J. Ahlquist, C. J. Umbarger, and A. K. Stokes, Health Physics 34, 486 (1978).

4. "A Germanium Detector System for the Detection of Transuranics at Low-Activity Concentrations in Soil," L. West, C. J. Umbarger, and T. Dempsey, Proceedings of the Eleventh Midyear Topical Symposium of the Health Physics Society on Radiation Instrumentation, San Diego, California, January 16-19, 1978.

5. "A New Ultra Small Battery Operated Multichannel Analyzer," M. A. Wolf and C. J. Umbarger, Proceedings of the IEEE Nuclear Science Symposium, San Francisco, CA, October 17-19, 1979.

6. "A Totally New Pocket Radiation Chirper," C. J. Umbarger and M. A. Wolf, Health Physics, 36, 455 (1979).

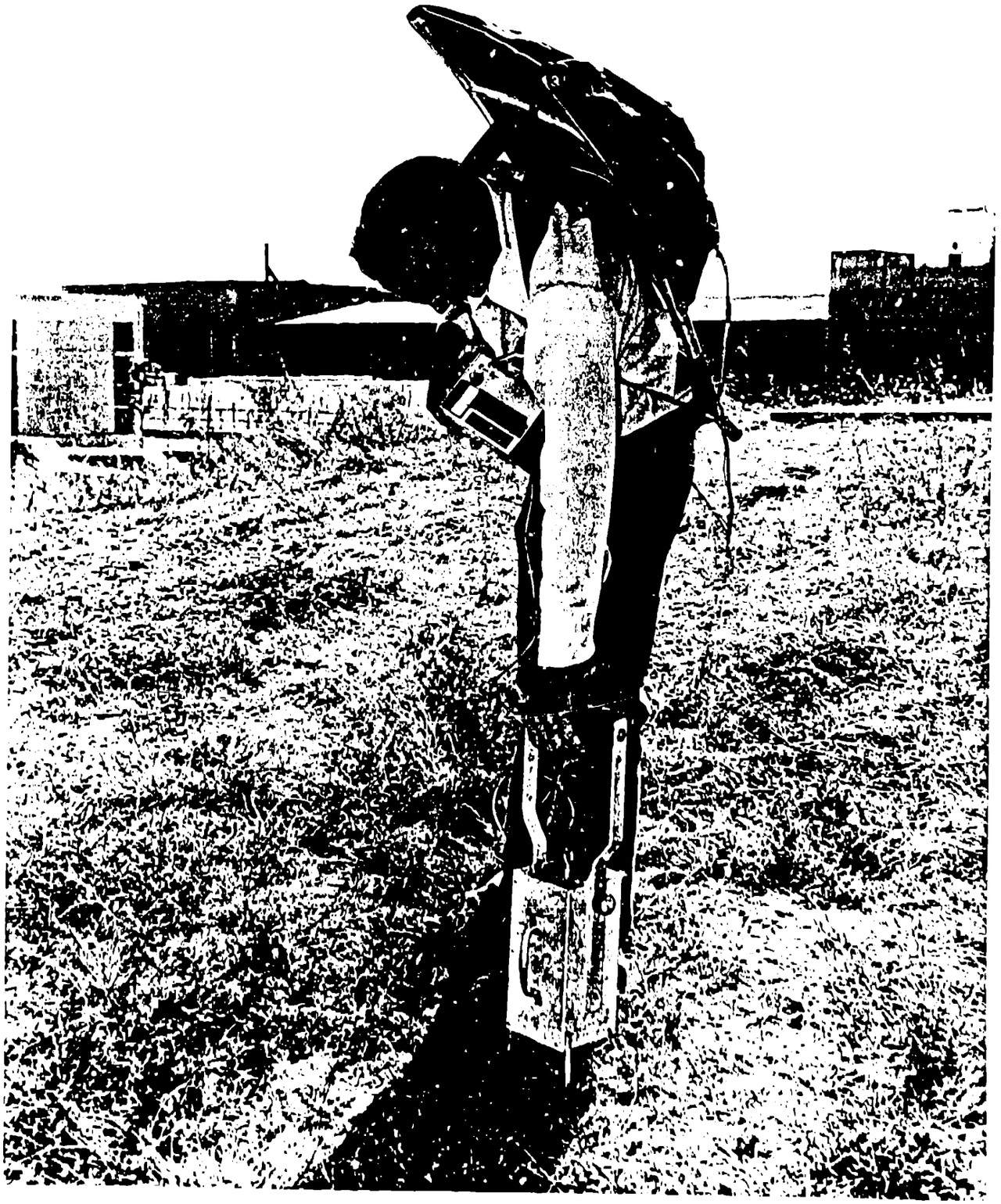
Figure Captions

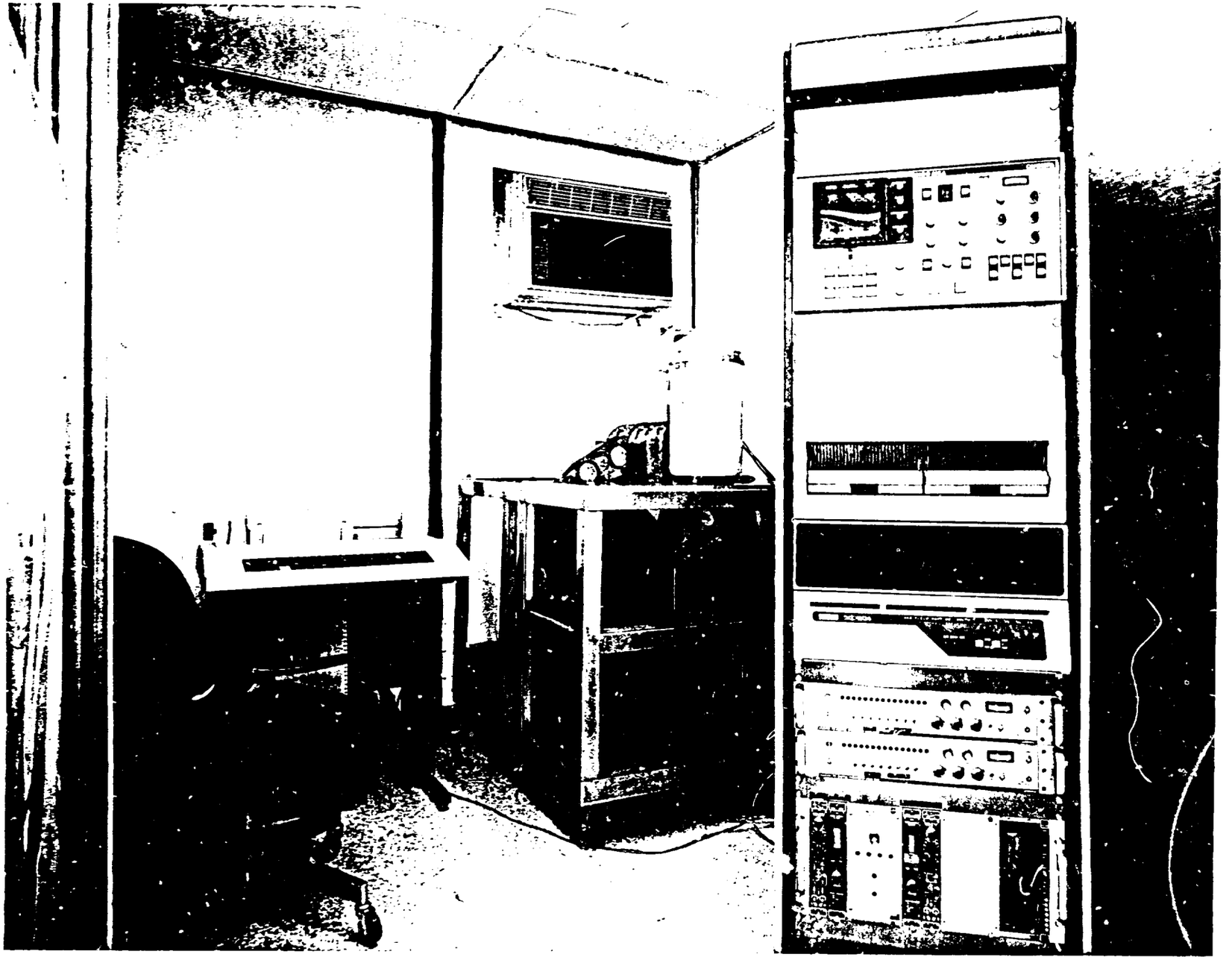
1. Field phoswich detector system for low level monitoring of TRU contamination.

2. Computer-controlled intrinsic germanium/Ge(Li)-based soil monitoring system. The white dewar on this side of the sample wheel contains the intrinsic germanium detector for quantifying TRU materials. A large volume Ge(Li) detector is directly opposite the sample and monitors for higher energy photon emitters such as ^{137}Cs.

3. Models 1 and 2 of the LASL portable MCA are shown with the portable intrinsic germanium photon detector in front. Both MCA's have 1024 channels with model 2 on the right having a builtin digital cassette recorder and extra PROM card that inserts into the top deck.

4. CdTe detector-based miniature radiation chirper. Note the nickel coin for size comparison.



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